GREY BILLY AND THE AGE OF TOR TOPOGRAPHY IN MONARO, N.S.W.

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(Plate v.)

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Synopsis.

Near Berridale tors and monoliths of granite are surrounded by sub-basaltic silicified sands and gravels (grey billy). The tor topography is thus Oligocene or older, not Pleistocene as usually assumed.

Introduction.

The present note was written primarily as the result of reading some entries in a field note-book of the late Sir Edgeworth David dating back to 1900. During his visits to Kosciusko, travelling by horse-drawn vehicle along the road from Cooma to Berridale and Jindabyne, he usually made copious geological notes on the rock formations encountered *en route*, and in particular examined a number of occurrences of grey billy, to some of which his attention had been drawn by Richard Helms, that most versatile and observant scientific collector from the Australian Museum. Interested in the Tertiary basalt and grey billy of the Monaro, my wife and I visited one of the occurrences mentioned by David and found the grey billy in such close proximity to some granite tors that it was possible to determine their relative ages. I am much indebted to my wife for help in the field work.

Grey Billy.

In this note the name "grey billy" is applied with its original significance to the quartzitic rocks—silicified sands and gravels—often found underlying Tertiary basalts and representing original terrestrial sediments, mainly alluvial, which have been altered by the basalt flows. Occurrences of these silicified deposits are fairly numerous in the eastern highland belt of New South Wales and have also been reported from Victoria and Queensland. In the author's experience they are quite abundant in the country east, west and south of Cooma, and it is with some of these, situated within the basin of the Snowy River, that it is proposed to deal in this paper. The grey billy appears in outcrop as a result of the erosion of the overlying basalt, and its presence in any given locality may be accepted with confidence as evidence of the former presence of Tertiary basalt there. In many instances the grey billy may be traced continuously to a point where it disappears under basalt.

With one doubtful exception which has been tentatively assigned a Pliocene age (Owen, 1954), the Tertiary basalts of this State are, so far as is known, Oligocene, a fact deduced on physiographic grounds and attested by palynological examination of associated sediments (Cookson and Pike, 1957; Voisey, 1956).

It is not proposed here to give a detailed account of grey billy. It occurs in layers about 3 to 6 feet thick and may rest on unsilicified clays, sands, gravels and occasionally impure peat beds. Pebbles in the silicified gravels may be of the white quartz so common in the gravels of rivers flowing over a *terrain* of clay-slate intersected by quartz-veins, but pebbles and boulders of other rock-types may be found completely silicified and still retaining traces of original structures. Where silicification has been incomplete sand grains may be etched out and appear in relief, pebbles may be loosened and drop out, and the billy outcrop may be weathered differentially into cavities. After exposure to the atmosphere the rock, broken up into large blocks and tilted through undermining, may be rounded, smoothed and dimpled and show polygonal superficial cracking, presenting a very characteristic appearance. The colour is mostly light grey, but where strongly iron-stained may be brown (Plate v, figs 1, 2 and 3).

It is obvious that remnants of the Tertiary basalt and grey billy scattered over a landscape may give important clues to early Tertiary palaeogeography, and indeed they have already been used to that end in New England (Voisey, 1942).

Tor Topography.

Development of tor topography is not confined to any particular rock-type, but is most commonly found in granitic *terrains*. Little attention appears to have been given to it by geologsts in this country, and here and elsewhere there seems to be a belief, implicit but seldom expressed, and not founded on any serious observation or reasoning, that it is a weathering phenomenon associated with the present cycle of erosion and produced through direct exposure of the rocks to the atmosphere. However, vertical sections in quarries and other excavations of certain susceptible rock-types like granite and dolerite, intersected by joint-cracks, commonly reveal a process of chemical weathering or rotting resulting from the downward passage of surface-waters seeping along the joint-cracks and spreading from them to leave rounded cores or kernels of fresh rock in the joint-blocks, surrounded by shells of decomposed material, the cores increasing in size with depth and in general disappearing completely near the surface. It is therefore most probable that, as envisaged by Blackwelder (1925), Davis (1938) and Linton (1955), tor topography originated through prolonged differential chemical weathering extending from the surface down to the water-table, where weathering ceases to operate, and that only when the rotted rock is removed by erosion, following, for example, slight or moderate uplift, are the residual blocks of undecomposed rock brought together and exposed in outcrop. As the intensity of weathering no doubt varies from point to point in the rock-mass in accordance with changes in composition and the frequency of joint-cracks, the stripped surface will not be completely plane, but certain remnants of fresh rock will stand up in relief.

Conditions for tor topography, therefore, would seem to be: (*a*) a *terrain* composed of silicate rocks susceptible to chemical weathering and intersected by joint-cracks; (*b*) an antecedent surface at an indeterminate height well above the top of the highest tor; (*c*) a prolonged interval of stillstand during which chemical weathering occurred; (*d*) a climate favouring deep decomposition of the rock (*e.g.*, high temperature and high rainfall); (*e*) subsequent moderate uplift and complete removal of the rotted rock by erosion.

Thus an area of tor topography may have important implications in regard to antecedent climate and earth-movements.

Tors and Grey Billy near Berridale.

The granite exhibiting the tor topography here considered is first encountered 8½ miles out of Cooma and is traversed by the Kosciusko road all the way to Berridale. It is part of a large bathylith extending from some 20 miles north of Berridale south through Dalgety almost to the Victorian border with a width of 10 or 12 miles. Much of it, especially on the eastern side, is covered with Oligocene basalt, and outcrops of grey billy indicate that the basalt-covered area was formerly more extensive. In places the basalt is underlain by sediments including impure peat-beds which may be altered to a kind of coal (Dulhunty, 1946). The granite forms undulating country with a general slope from the Main Divide to the south-west, its elevation ranging from 3,600 feet a few miles east of the Cooma aerodrome to 2,500 feet at Dalgety.

At a point some 17½ miles from Cooma and one mile past the Rocky Plain turn-off is a small lake known locally as Spring Creek Lake (though it is actually on a tributary valley of Spring Creek), on the property known as "Glendale". It is half a mile S.E. of the road at an approximate altitude of 2,860 feet and is some 200 yards in diameter, in a broad, shallow valley trending in a general southerly direction. The lake is more or less surrounded by grey billy, which rises on the southern shore to a little "plateau" 30 feet above it, resting on granite, and slopes down into the lake (Pl. v, fig. 1). It may be traced upstream from the lake to the Berridale road, and eastward at intervals over flat country for upwards of ¾ mile towards a low hill of basalt overlying ferruginous grit resting on granite at 2,900 feet; this may have been on the slope of the original valley-wall. On the northern side of the lake the grey billy includes silicified grits, gravel and boulder beds as well as sands (Pl. v, figs 1, 2 and 3). Locally, owing to imperfect silicification, it is somewhat cavernous. It is apparent that the billy is on the site of a wide, flat-floored, shallow pre-basalt river valley cut in the granite, now occupied by two tributaries of Spring Creek.

Some 400 yards south of the lake is an east-west line of tor-like masses of granite forming a narrow irregular ridge above the general level, the most easterly group rising 25 or 30 feet (Pl. v, fig. 4). Though essentially *in situ*, the granite has been slightly disrupted along joint-planes and some of the rounded joint-blocks have been displaced.

Between this ridge and the billy "plateau" is a shallow col with a few beehive or dome-shaped outcrops of granite up to seven feet high, completely surrounded by low isolated patches of grey billy appearing just above the surface soil (Pl. v, fig. 5), and these may also be traced around the base of the eastern side of the tor ridge to its southern side. These low outcrops of billy were evidently once completely soil-covered and have been bared by sheet-erosion since the clearing and stocking of the country; it is highly probable that they are continuous beneath a thin soil cover. Near the edge of the little "plateau" grey billy outcrops up to 4 or 5 feet high are seen close to and almost completely encircling a little granite dome (Pl. v, fig. 6). Not far away are two groups or lines of granite outcrops 40 or 50 yards apart and up to about 15 feet high, with low outcrops of billy at ground level between them. At one point on the western edge of the "plateau" two granite blocks a few feet high are separated by a space about six feet wide filled with grey billy. There can be no room for doubt that the granite tors and monoliths, great and small, were in existence as such before the Oligocene basalt was poured out and before the sub-basaltic sediments were laid down. True there has been some shrinkage of the granite masses through exfoliation and other weathering effects subsequently to their exhumation, but not to a significant extent.

Age of the Tor Topography.

Thus it is clear that the tor topography around Spring Creek Lake, being pre-basalt, is Oligocene or older. It is reasonable to infer that the same is true of all the tor topography in the granite area, and it is probable that diligent search would reveal further examples of grey billy or of basalt in contact with granite tors or monoliths. Indeed Mr. A. B. Costin, of C.S.I.R.O., has kindly drawn my attention to one such occurrence some 600 yards north of the road about two miles from Berridale towards Cooma, where there is a low granitic rise at about 2,830 feet, studded with granite monoliths 5 or 6 feet high having grey billy between them. The latter, partly of silicified gravel, must cover several acres and is apparently related to an Oligocene ancestor of the nearby Wullwye Creek. Again, some 12 miles to the S.S.E., where the road from Maffra to Dalgety descends to the valley of Bobundarah Creek, the left bank of the valley, cut in granite to a depth of 300 feet, shows an abundance of granite monoliths with basalt, part of a former valley-filling, forming a capping. Though the two rocks have not been seen in actual contact, it is almost certain that the monoliths existed as such in Oligocene time and were buried beneath basalt.

It is generally accepted that deep chemical weathering is a function of climate and that deep decomposition of granite is promoted by hot and moist conditions. If this is correct it may be assumed that the climate prevailing in the neighbourhood of Cooma and Berridale in early Tertiary time approached tropicality. The topographic conditions most favourable to the deep weathering would be those characterized by prolonged stability, with very gentle slopes and sluggish streams, in other words peneplain conditions.

History of the Tor Topography.

The existence of an extensive late-Cretaceous peneplain in eastern Australia has been postulated by Australian geologists (Andrews, 1914; David, 1950), and it is believed to have experienced elevation and dissection in the early Tertiary. It may, therefore, be tentatively suggested that in the Cooma-Berridale area during a long period of Cretaceous peneplanation the granite in suitable situations was decomposed to a considerable but unknown depth. About the close of Eocene time moderate uplift rejuvenated the senile streams and revived erosion, so that the regolith of rotted granite was in the course of time removed, producing a tor topography. This was preserved from destruction by being completely buried under great floods of Oligocene basalt and was later slowly exhumed by the descendants of the early Tertiary streams which had been responsible for laying it bare in the first instance, revealing a palimpsest topography. Ample evidence of the activity of the Oligocene revived streams is provided by the existing tributaries of the Snowy, which have partially removed the basalt fillings and revealed old valleys, in places up to two miles wide, excavated in the granite to depths of more than 200 feet. Exhumation probably began in Pliocene time and has continued to the present day.

Tor topography is not uncommon in granite country elsewhere in New South Wales, partially overlain by Oligocene basalt, as in New England. Some of it may conceivably prove to be, like that herein described, of early Tertiary age.

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EXPLANATION OF PLATE V.

Fig. 1.—Looking south towards Spring Creek Lake with the grey billy "plateau" in right background. In foreground grey billy with bed of silicified gravel, broken into blocks and tilted. Note differential weathering of gravel layer due to incomplete silicification.

Fig. 2.—Silicified boulder-bed. The original boulders are completely replaced by silica.

Fig. 3.—Block of grey billy smoothed, dimpled and polygonally cracked.

Fig. 4.—Looking south at the eastern end of the tor ridge. A few low, white outcrops of grey billy in foreground, at approximately the level of the "plateau", below and to right and left of figure.

Fig. 5.—Rounded granite monolith 7 ft. high, with small, flat outcrops of grey billy around it. In background the wide, shallow valley with granite outcrops marking the far bank.

Fig. 6.—Beehive-shaped outcrop of granite 4 ft. high, in middle foreground, with outcrops of somewhat cavernous grey billy around it.